PLANNING AND IMPACT OF DISTRIBUTED GENERATION IN SESB EXISTING SYSTEM

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For my beloved mother and father

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ABSTRACT

In the recent years the electrical power networks are undergoing rapid restructuring and developing process worldwide. Advancement in technologies and concern about the environmental impacts have led to increase interconnection of renewable energy based distributed generations (DGs) in distribution networks. The DGs have significant impacts on the distribution systems; these impacts may be either positively or negatively depending on the modified interconnected DG distribution network structure. It will be necessary to consider many issues concerning these impacts. In this project, an investigation of DGs impacts on voltage profile and power losses in radial distribution networks is introduced and explained. The method of determining size and placing the DG unit using classical grid algorithm search has been analyses in this report. The performance of the interconnected DG distribution network in terms of power losses and voltage profile also has been analyzed. A comparison between many cases with different numbers, sizes and locations of interconnected DGs are considered and discussed. Detailed simulations using PSS ADEPT are conducted in order to explain and verify the results. At the end of this project, the result showed the significant improvement in terms of power losses and voltage stability.

ABSTRAK

Pada tahun kebelakangan ini rangkaian kuasa elektrik sedang menjalani penyusunan semula yang pesat membangun di seluruh dunia. Kemajuan dalam teknologi dan kebimbangan mengenai kesan alam sekitar telah membawa kepada peningkatan keperluan tenaga boleh diperbaharui dengan menggunakan Pembahagian Penjanaan (DG) dalam rangkaian pembahagian. Dimana DG memberi kesan ketara ke atas sistem pembahagian iaitu impak dari segi positif dan negatif. Namun ianya bergantung kepada struktur rangkaian pengedaran DG yang telah diubah suai. Perkara ini diambil kira kerana banyak isu-isu berkaitan impak ini perlu diketahui. Dalam projek ini, analisis impak DG pada profail voltan dan kehilangan kuasa dalam taburan rangkaian pembahagian diperkenalkan dan dijelaskan. Kaedah penentuan saiz dan lokasi penyambungan DG menggunakan algoritma carian grid klasik telah digunakan dalam laporan ini. Prestasi rangkaian pembahagian DG dari segi kehilangan kuasa dan profail voltan serta perbezaan senario yang pelbagai dengan cara menggunakan saiz unit dan lokasi DG yang berbeza dianalisa dan dibincangkan. Simulasi terperinci menggunakan PSS ADEPT dijalankan untuk menjelaskan dan mengesahkan keputusan analisa. Pada akhir projek ini keputusan menunjukkan peningkatan yang ketara dari segi kehilangan kuasa dan kestabilan voltan.

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LIST OF SYMBOLS AND ABBREVIATIONS

P	-	Active power
P_{Loss}	-	Active power losses
S	-	Apparent power
DG	-	Distributed Generation
P_{DG}	-	Distributed Generation size (in power)
PV	-	Generation Buses
$\geq$	-	Greater than or equal to
KW	-	Kilo Watts
$\leq$	-	Less than or equal to
X	-	Line reactance
PQ	-	Load Buses
MW	-	Mega Watts
%	-	Percentage
p.u	-	Per Unit
Q	-	Reactive power
Q_{Loss}	-	Reactive power losses
Δ	-	Step Size
$\sum$	-	Sum
AC	-	Alternative Current
DC	-	Direct Current
SESB	-	Sabah Electricity Sdn. Bhd.

CHAPTER 1

INTRODUCTION

1.1 Traditional Concept of Power Systems

Currently, most of the power systems generate and supplies electricity having into account the following considerations [1],[2]:

(i). Electricity generation is produced in large power plants, usually located close to the primary energy source (for instance: coil mines) and far away from the consumer centers.

(ii). Electricity is delivered to the customers using a large passive distribution infrastructure, which involves high voltage (HV), medium voltage (MV) and low voltage (LV) networks.

(iii). These distribution networks are designed to operate radially. The power flows only in one direction: from upper voltage levels down-to customers situated along the radial feeders.

(iv). In this process, there are three stages to be passed through before the power reaching the final user, i.e. generation, transmission and distribution.

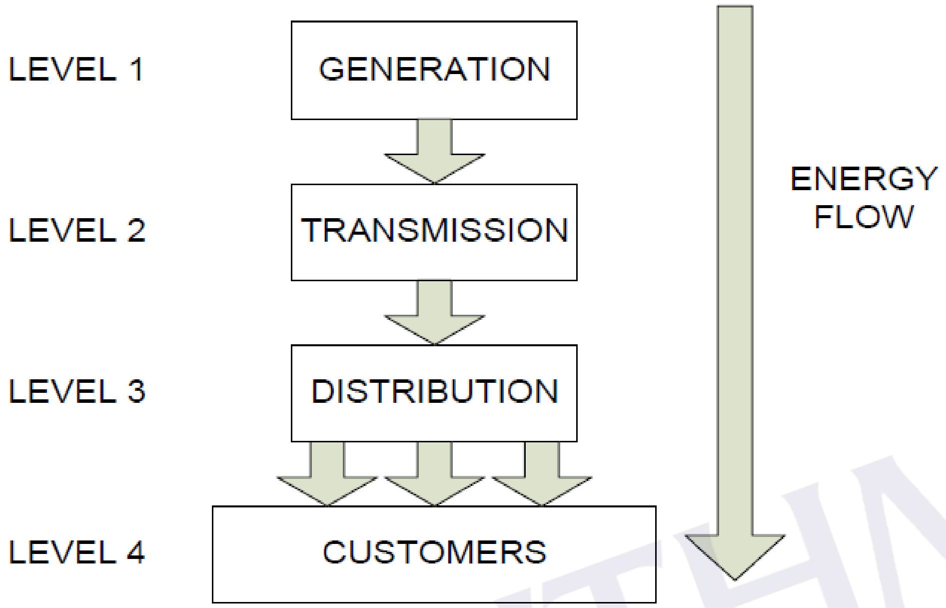

Figure 1.1: Traditional industrial conception of the electrical energy supply

In the first stage the electricity is generated in large generation plants, located in non-populated areas away from loads to get round with the economics of size and environmental issues. Second stage is accomplished with the support of various equipment such as transformers, overhead transmission lines and underground cables. The last stage is the distribution, the link between the utility system and the end customers. This stage is the most important part of the power system, as the final power quality depends on its reliability [2].

The electricity demand is increasing continuously. Consequently, electricity generation must increase in order to meet the demand requirements. Traditional power systems face this growth, installing new support systems in level 1 (see figure 1.1). Whilst, addition in the transmission and distribution levels are less frequent.

1.2 New Concept of Power Systems

Nowadays, the technological evolution, environmental policies, and also the expansion of the finance and electrical markets, are promoting new conditions in the sector of the electricity generation [2].

New technologies allow the electricity to be generated in small sized plants. Moreover, the increasing use of renewable sources in order to reduce the environmental impact of power generation leads to the development and application of new electrical energy supply schemes.

In this new conception, the generation is not exclusive to level 1. Hence some of the energy-demand is supplied by the centralized generation and another part is produced by *distributed generation*. The electricity is going to be produced closer to the customers.

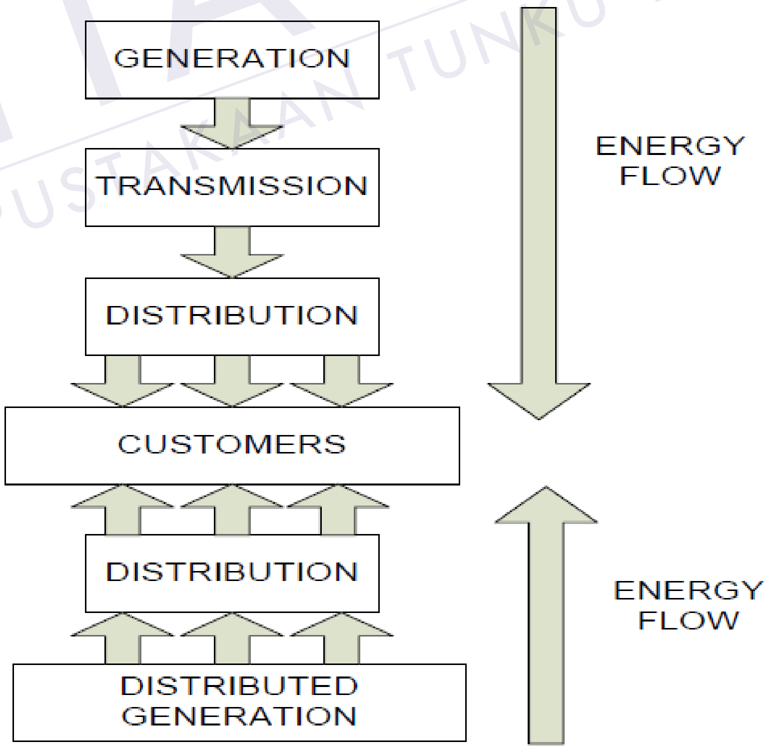

Figure 1.2: New industrial conception of the electrical energy supply

1.3 Distributed Generation

Trends in energy consumption requirements, and in the evolution of electricity generation and storage technologies, will ultimately fuel a boom DG, a solution that offers the best long-term answer to questions of reliability, price, and pollution. DG is generally defined as generation, storage, or devices that are connected to, or injected into, the distribution lines of the electricity grid. They may be located at a customer's premises on either side of the meter or may be located at other points on the distribution line, such as a utility substation [1]. DG is integrated with different sizes and different technologies at distribution levels. The planning of electric systems with the presence of DG requires the definition of several factors, such as: the best technology to be used, the number and capacity of the units, the best location, the network connection way, etc. Large scale integration of distributed generators at either LV or MV is at the present the trend followed in power systems to cover the supply of some loads. These generators are of considerable smaller size than the traditional generators (thermal, nuclear, etc…) [3]. An overview of some common benefits and drawbacks of the DG are presented below:

(a) Benefits [4]

i. Connection of DG is intended to increase the reliability of power supply provided to the customers, using local sources, and if possible, reduce the losses of the transmission and distribution systems.

ii. The connection of DG to the power system could improve the voltage profile, power quality and support voltage stability. Therefore, the system can withstand higher loading situations.

iii. The installation of DG takes less time and payback period. Many countries are subsidizing the development of renewable energy projects through a portfolio obligation and green power certificates. This incentives investment in small generation plants.

iv. Some DG technologies have low pollution and good overall efficiencies like combined heat and power (CHP) and micro-turbines. Besides, renewable energy based DG like photovoltaic and wind turbines contribute to the reduction of greenhouse gases.

(b) Drawbacks [4]

i. Many DG are connected to the grid via power converters, which injects harmonics into the system.

ii. The connection of DG might cause over-voltage, fluctuation and unbalance of the system voltage if coordination with the utility supply is not properly achieved.

iii. Depending on the network configuration, the penetration level and the nature of the DG technology, the power injection of DG may increase the power losses in the distribution system.

iv. Short circuit levels are changed when a DG is connected to the network. Therefore, relay settings should be changed and if there is a disconnection of DG, relay should be changed back to its previous state.

1.4 Problem Statements

In Sabah, the total generation capacity of Sabah Electricity Sdn. Bhd. (SESB) is 866.4 MW. 50.3% of the total units generated are purchased from the independent power producers (IPP). SESB installed capacity excluding IPP, of the Sabah Grid which supplies electricity for major towns from Federal Territory Labuan to Tawau is 430.9 MW and the maximum demand is 760 MW.

The East Coast Grid 132kV Transmission Line connecting the major towns in the East Coast has an installed capacity of 333.02MW and the maximum demand is 203.3MW. The forecast demand growth of electricity is in a region of 7.7% per annum up to the year 2010 and the electricity demand is expected to reach 1,500 MW by the year 2020. In order to support the growing demand, various generations, transmission and distribution projects will be implemented. A fully integrated grid connecting the West Coast Grid to the East Coast Grid was completed on 2007, and about 90% of the customers are now connected to this integrated grid.

However, electricity interruption is one of the major problems that always been criticized by users in Sabah. At the end of September 2013 More than 500,000 consumers in Sabah and Labuan has been affected due to the insufficient generation power injected to grid while restoration works were being carried out by the three Independent Power Producer (IPP) stations in Sepanggar. Because of the unexpected incidents, SESB has been carried out staggered rationing for about one month, up to three hours on working days.

From this problem, it is a perfect time for SESB to consider applying a new technology that even more reliable called Distributed Generation scheme. DG could be considered as one of the most viable options to ease some of the problems (e.g. high loss, low reliability, poor power quality and congestion in transmission systems) faced by power systems, apart from meeting the energy demand of ever growing loads. In addition, the modular and small size of the DG will facilitate the planner to install it in a shorter time frame compared to the conventional solution. It would be more beneficial to install in a more decentralized environment where there is a larger uncertainty in demand and supply.

However, given the choices, they need to be placed in appropriate locations with suitable sizes. Therefore, analysis tools are needed to be developed to examine locations and the sizing of such DG installations. Thus, this project modified the economic dispatch method to determine the optimum size and location of DG in the distribution network, and to analyze the impact of DG in term of power losses and voltage profile.

1.5 Project Objectives

The major objective of this project is to perform a system study on the impact of load losses and voltage stability when connected to DG in different scenarios.

Its measurable objectives are as follows:

i. The main objective of this project is to present a simulation approach to study about distributed generation in term of to identify and determine the suitable size and location to install DG.

ii. The second objective is to analyse the impact of applying DG to the existing network in term of power losses and voltage profile in SESB distribution systems.

1.6 Project Scopes

The scopes of this project are:

i. To analysing the proper size and location to install DG in distribution system using PSS ADEPT.

ii. To analysing the impact of system losses and voltage profile when DG applied in the existing system. The system develop in this project has been limited to PPU Batu Sapi, Sandakan region only through Sabah Electricity Sdn Bhd (SESB) data without any segmentation of countries and localization.

1.7 Outline of the Report

This report contains 5 chapters and appendices. It is organized as follows:

Chapter 1: Introduction

This chapter gives a brief introduction to the concept of distributed generation reflecting the importance of DG systems to both the utility network and customers, besides the drawbacks occurring if DG is connected to the distribution systems.

Chapter 2: Literature Review

This chapter is divided into six sections: the first section is a brief introduction and a definition of DG, followed by the second section which discusses the various types of distributed generation technologies and their nature. The impacts of DG on power system grids are discussed in the third section. Section four high lights one of the most important issues to maintain a safe operation of the DG, the protection coordination. Section five is an overview of one of the major problems, islanding, that miss-protection can lead to and causes difficulties in system restoration. Finally the last section discusses the previous study about DG made by other.

Chapter 3: Methodology

This chapter is to present the method proposed to do the analysis about DG in terms of load power flow, voltage stability, active and reactive power losses.

Chapter 4: Results and Discussions

In this chapter, simulations results with different DG configurations are presented. Software used for simulation is PSS ADEPT.

Chapter 5: Conclusions and Recommendations

Some conclusions are presented in this chapter. The chapter ends naming some of the works that can be done in the future with reference to the work presented in this research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Distributed Generation (DG) is one of the new trends in power systems used to support the increased energy-demand. There is not a common accepted definition of DG as the concept involves many technologies and applications. Different countries use different notations like “embedded generation”, “dispersed generation” or “decentralized generation”.

Furthermore, there are variations in the definition proposed by different organizations (IEEE, CIGRE…) that may cause confusion. Therefore in this project, the following definition is used [8]:

Distributed generation is considered as an electrical source connected to the power system, in a point very close to/or at consumer´s site, which is small enough compared with the centralized power plants.

To clarify about the DG concept, some categories that define the size of the generation unit are presented in Table 2.1.

Table 2.1: Size of DG

Size of the DG [10]

Type	Size
Micro distributed generation	1Watt < 5kW
Small distributed generation	5kW < 5 MW
Medium distributed generation	5 MW < 50MW
Large distributed generation	50MW < 300MW

The different DG technologies and impacts of distributed generation are introduced in this chapter; besides, islanded operation and the impact of DG on distribution feeder protection are presented.

2.2 Types of Distributed Generation

DG can be classified into two major groups, inverter based DG and rotating machine DG. Normally, inverters are used in DG systems after the generation process, as the generated voltage may be in DC or AC form, but it is required to be changed to the nominal voltage and frequency. Therefore, it has to be converted first to DC and then back to AC with the nominal parameters through the rectifier [10]. In this chapter, some of the DG technologies, which are available at the present: photovoltaic systems, wind turbines, fuel cells, micro turbines, synchronous and induction generators are introduced.

2.2.1 Photovoltaic Systems

A photovoltaic system, converts the light received from the sun into electric energy. In this system, semiconductive materials are used in the construction of solar cells, which transform the self-contained energy of photons into electricity, when they are exposed to sun light. The cells are placed in an array that is either fixed or moving to keep tracking the sun in order to generate the maximum power [9].

These systems are environmental friendly without any kind of emission, easy to use, with simple designs and it does not require any other fuel than solar light. On the other hand, they need large spaces and the initial cost is high. In Figure 2.1, a photovoltaic panel is shown.

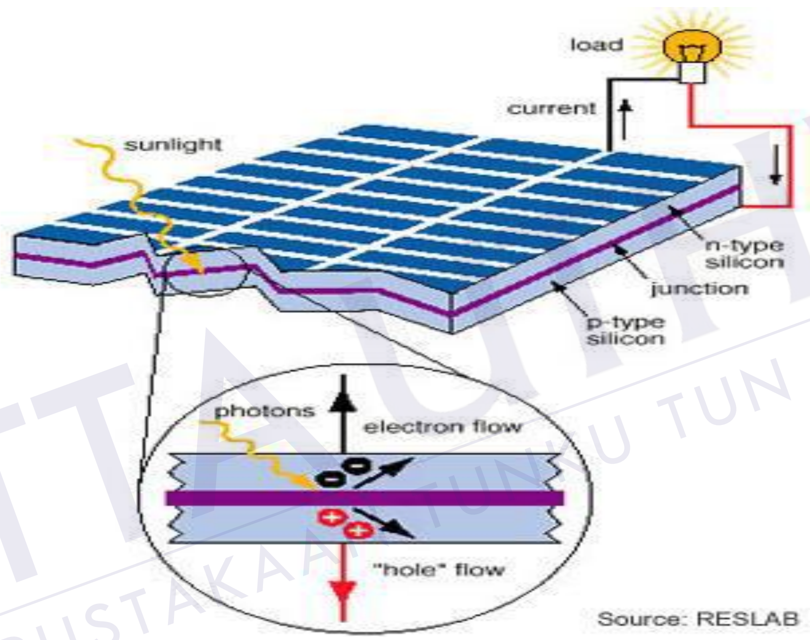

Figure 2.1: Schematic diagram of a photovoltaic system [11]

PV systems generate DC voltage then transferred to AC with the aid of inverters. There are two general designs that are typically used: with and without battery storages.

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